

**The Life History of *Ophraella notulata* (F.) on Western Ragweed,
Ambrosia psilostachya De Candolle, in Southern California
(Coleoptera: Chrysomelidae)**

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Despite an extensive and intensive survey of the phytophagous insect fauna of western ragweed, *Ambrosia psilostachya*, in southern California during 1968–1970, we failed to detect and hence did not include *Ophraella notulata* among the 130+ insect species reported from this widespread native plant (Goeden and Ricker, 1976c). However, while sweeping plants along Kitchen Creek at the southern end of the Laguna Mountains in San Diego Co. on October 17, 1979, we encountered this beetle on western ragweed from which it is now reported, presumably for the first time from California (Wilcox, 1965; Welch, 1978).

Distribution and host plants.—Wilcox (1965) listed *O. notulata* in North America from as far west as Arizona. Welch (1978) described its distribution as “. . . throughout most of the continental United States, parts of Canada . . . , and as far south as Guatemala . . .” exclusively on so-called “common ragweed,” *A. artemisiifolia* (F.). He noted the apparent absence of common ragweed and *O. notulata* from southern California, the latter supposition based on our still valid, negative collection records from several other native ragweeds (Goeden and Ricker, 1974, 1976b). We also have collected eggs, larvae, and adults of *O. notulata* at Kitchen Creek from cocklebur, *Xanthium strumarium* L., a close ragweed relative, from which this leaf beetle is newly reported (Hilgendorf and Goeden, 1982, 1983). In the insectary, *O. notulata* additionally has been reared from egg to adult on potted plants of *A. chenopodiifolia* (Benth) Payne, *A. confertiflora* De Candolle, *A. dumosa* (Gray) Payne, *A. eriocentra* (Gray) Payne, and *A. ilicifolia* (Gray) Payne. Apparently, none of these ragweeds is attacked by *O. notulata* in nature (Goeden and Ricker, 1975, 1976a, 1976b).

Biology.—The biology of *O. notulata* was studied in the field on western ragweed at Kitchen Creek during 1979–1982, and in the insectary of the Division of Biological Control, University of California, Riverside, at $27 \pm 1^\circ\text{C}$, 40–70% relative humidity, and a 16/8-hr (light/dark) photoperiod. This supplements the study by Welch (1978) of *O. notulata* on common ragweed in Connecticut.

Egg.—Welch (1978) described the pyriform eggs (Fig. 1a) and illustrated the microscopic, hexagonal sculpturing of the chorion. Fifty eggs from our insectary culture measured 0.05 mm smaller in mean greatest width, but otherwise fit his description.

In insectary cagings, most fertile eggs were lightly, but firmly glued at their larger ends in clusters to the leaves of potted plants or bouquets of freshly excised branches. A few (<1%) infertile eggs also were found within these egg masses. Infertile eggs produced by unmated females and by older females towards the end of their oviposition periods were loosely scattered individually or in small, irreg-

ular clusters on the foliage and cage surfaces. Of 456 masses of fertile eggs examined, 296 (64.9%) were compact, elongate clusters (Fig. 1a); 91 (20.0%) were linear, single or double-ranked series; and 69 (15.1%) were loose, irregular clusters. Of 654 egg masses examined, 590 (90.2%) were laid on the undersides of leaves; the remainder, on the adaxial leaf surfaces. Many of the latter clusters were laid on leaves bent sharply upward or downward from their usual, nearly horizontal positions. Of 679 egg clusters examined, 212 (32.3%) were attached to a lateral lobe of a leaf alongside or straddled a primary vein, 143 (21.1%) were deposited on the terminal leaf lobe and commonly straddled the midrib, 57 (8.4%) were located in the angle of the midrib and a primary lateral vein, 44 (6.5%) were laid on a basal leaf lobe, and 4 (0.6%) were attached to a petiole wing. A simple experiment indicated that this egg placement partly was a response to gravity, as all 22 egg clusters laid on the leaves of 5 straight branches held vertically, but reversed 180°, were attached to the upside-down, adaxial leaf surfaces.

An average of 13.3 ± 0.2 (\pm SE) (range: 2–41) eggs were counted in 833 clusters recovered from insectary cagings. The distribution of eggs per mass was skewed such that only 41 (ca. 5%) of these clusters contained 23 or more eggs. Few fertile eggs were laid singly. Welch (1978) reported much larger masses averaging 36 eggs in his cagings.

Field observations on egg mass placement and size supported our insectary findings. At Kitchen Creek, 21 egg masses were found attached to the underside of cauline leaves located an average of 18 ± 1.7 (range: 5–35) cm below the apical, staminate inflorescences and 13 ± 1.6 (range: 0–30) cm above the lowest, living leaves on mature plants.

Larva.—Eggs hatched in 5 or 6 days in the insectary. The first instars emerged headfirst through irregular holes chewed in the chorions just below and lateral of the apical papillae (Fig. 1b). Larvae from the same egg mass usually hatched within a few hours of each other. Some masses apparently consisted of eggs laid by the same or different females on successive days. Embryonic development and hatching were delayed for a distinct segment of the eggs in such masses, which probably were artifacts of insectary culture. Eclosion took as little as 10 min. The empty chorion was abandoned and leaf feeding began as soon as 1 min after eclosion.

Welch (1978) reported head capsule measurements for each of the 3 instars. In insectary rearings of 21 isolated larvae on bouquets of fresh branch terminals, larval development lasted 12 ± 0.6 (range: 12–14) days. An average of 3.5 ± 0.1 (range: 3–4) days (ca. 30%) at the end of this period was spent as a nonfeeding prepupa in a coarse silk cocoon. This prepupal period averaged a day longer than Welch (1978) reported. On western ragweed, the first larval stadium lasted 4 days; the second stadium, 2–3 days; and the third stadium, 5–7 days. The larvae grew in length from 1.0–2.4 mm as first instars to 3.5–7.0 mm as third instars.

Feeding symptoms of the first instars were small “shot-hole” lesions in the nearer epidermis and mesophyll to, but not through, the opposite epidermis. This instar fed somewhat gregariously for a day or so, then began to disperse both upward and downward on the stems to feed as scattered individuals or in small groups. Molting, like feeding, usually occurred on the underside of a leaf, although some first instars fed and molted atop leaves. Second instars fed as scattered individuals and usually molted on the underside of leaves. Third instars skele-

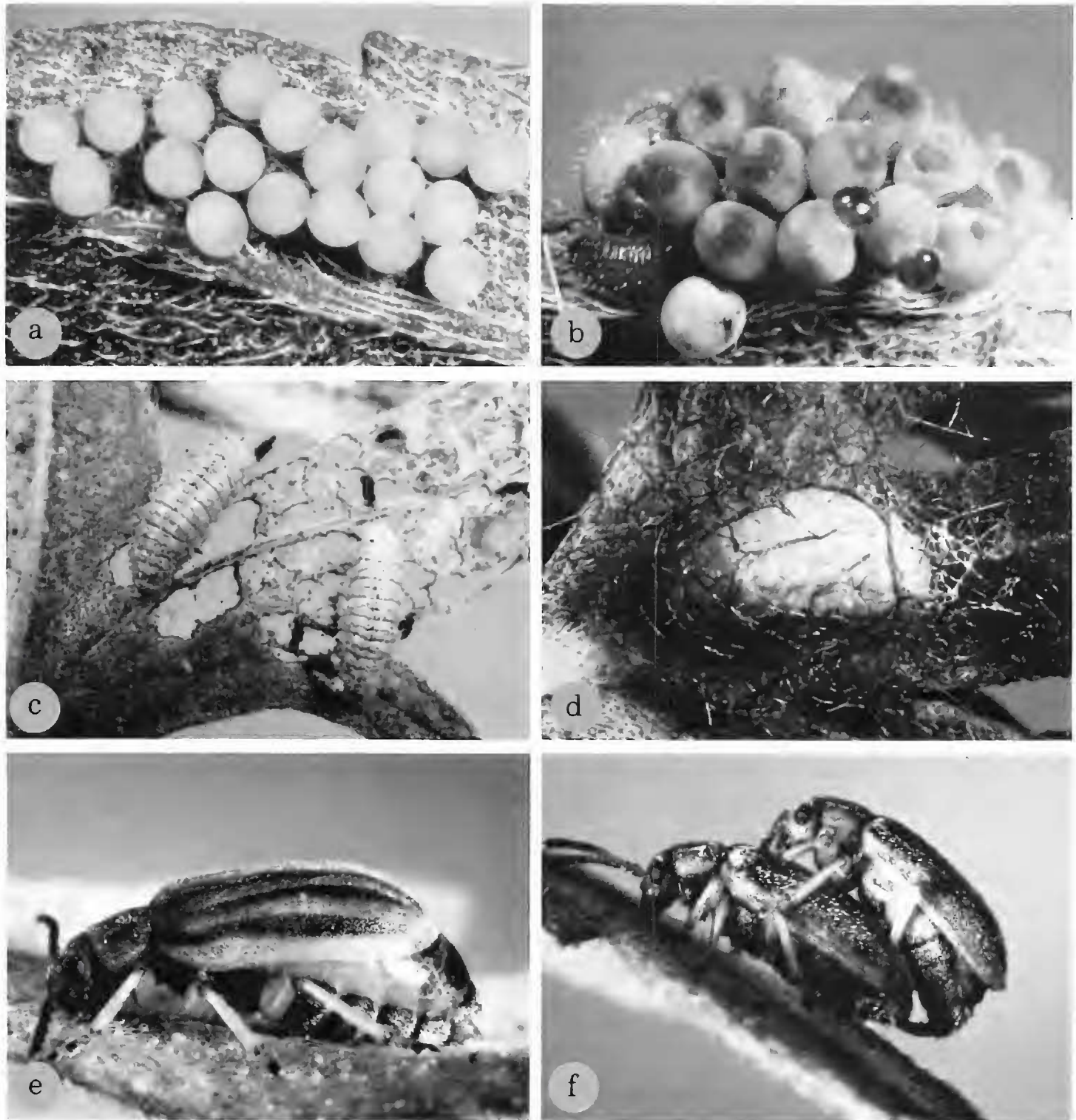


Figure 1. Life stages of *Ophraella notulata*. (a) Egg mass, 13 \times . (b) Newly hatched larvae, 17.3 \times . (c) Third instars and feeding damage on leaf of western ragweed, 4.1 \times . (d) Cocoon containing prepupa, 6.7 \times . (e) Gravid female, 8 \times . (f) Adults *in copula*, 6.8 \times .

tonized the leaves from the upper and lower surfaces and left the midribs, primary lateral veins, and opposite epidermis largely intact (Fig. 1c). Dark brown-black, subcylindrical, fecal pellets littered the foliage upon which the larvae fed, the foliage beneath, as well as the cage floors. Unlike Welch (1978), we observed no tendency for the larvae to migrate at dusk toward the terminal growth of potted plants caged either in the insectary or in a sunlit greenhouse.

The fully grown third instar usually began construction of its cocoon away from feeding areas on the upper surface of a leaf along and over a midrib or a lateral vein. Cocoon formation was initiated at various times of the day and night and continued to completion during both the photophase and scotophase. The first step in cocoon formation was the stringing of several, transverse, silk strands

between the leaf or leaf lobe margins across the larval dorsum. Contrary to Welch (1978), who reported the silk to be a "maxillary secretion," we found it to issue as a clear, viscous liquid from an opening on the prosternum between the fore coxae. The gland orifice is a narrow, circular, sclerotized ring that appears two-lipped when closed. The head of the larva periodically dipped postero-ventrally as it secured additional mouthfuls of this secretion. The thoracic sterna and coxae shone from a coating of the secretion. The freshly formed, clear, silk strands darkened to golden yellow, then to reddish brown. After several transverse strands were laid, the process began of joining them with other strands and connecting these to the leaf surface and margins. The strands from which the cocoon was fashioned were irregular in length and diameter and formed an open meshwork through which the contents could be seen (Fig. 1d). Strands were thickened (1) by running a single strand between the mouthparts while depositing a coating of the secretion, (2) by coating in a similar manner 2 or more strands held together with the mouthparts, and (3) by incorporating plant hairs broken or chewed from the leaf surface into the strand coating. The fore legs and mouthparts were used to manipulate the strands while spinning. The surface of the leaf upon which the cocoon was formed was kept relatively free of silk and rubbed smooth by the body movements of the larva. The larva moved actively about within the cocoon under construction by adhering to the leaf surface with its posterior, ventral "proleg" or by grasping the webbing from inside with its middle and hind legs. Turning itself end-over-end, the larva arched its dorsum upward against the forming cocoon and thus used its body as a template to shape this structure. The larva rested periodically during cocoon formation and these resting periods became longer as the cocoon neared completion. The finished cocoon (Fig. 1d) had a flattened teardrop shape inside that was roughly twice the width and one and a half the height of the larva. Externally, the cocoon lay appressed to the leaf surface and tapered at one end to a semicircular opening; the other end was rounded and closed inside, but flared outward externally. One larva was observed to take 7½ hr to complete its cocoon.

Pupa.—Prior to pupation the larva partially backed out through the open mouth of its cocoon and voided a pile of dark, liquid feces on the leaf surface. Molting subsequently occurred inside the cocoon, where the cast exuviae usually was deposited behind the exarate pupa at the inner mouth of the cocoon. The pupal stage of 19 individuals averaged 4 ± 0.1 (range: 3–4) days in the insectary.

Adult.—The adult (Fig. 1e, f) was described in detail by Horn (1983). Welch (1978) illustrated an adult in dorsal view and the terminal, abdominal, sternal characters useful in separating the sexes.

Beetles emerged from cocoons through holes usually chewed in the end opposite the cocoon opening, but occasionally exited through the top or at the same end as the opening. Like Welch (1978), we noted that adults emerged only during the photophase. Depending on the generation involved, the emerged adults feed on leaves, mate, and either reproduce or overwinter as discussed below. Also like Welch (1978), we noted that mating could occur within 1 or 2 days after beetle emergence in the insectary.

All of 6 females individually reared from eggs in the insectary initially oviposited 5 days after they had molted to adults within their cocoons. Each of 21 mating pairs collected at Kitchen Creek on October 17, 1979, were caged separately with

an excised branch of western ragweed which was checked for eggs and replaced daily during the oviposition period of each female. These beetles normally would have overwintered and not have reproduced until the following summer; however, after feeding under insectary conditions, the females began to oviposit in an average of 9 ± 1 (range: 3–21) days. Fourteen of the 21 females that subsequently were not accidentally killed or escaped laid an average of 667 ± 60 (range: 385–1206) eggs during a 66 ± 6 (range: 32–106) day oviposition period. Based only on the days when they oviposited, an average of 45 ± 4 (range: 25–67) days each, these 14 beetles laid 15 ± 0.4 (range: 1–57) eggs daily. These females were observed *in copula* (Fig. 1f) an average of 5 (range: 3–11) times and lived an average of 9 (range: 1–14) days after they ceased oviposition. The 16 males that did not die prematurely or escape lived 151 ± 14 (range: 83–260) days after they were collected; the 14 females that oviposited lived 83 ± 7 (range: 42–123) days after they were collected.

Seasonal history.—*Ophraella notulata* is multivoltine in southern California. The beetles overwinter as mated adults, which Welch (1978) also reported from Connecticut. The earliest date that we swept beetles from vegetative shoots of western ragweed at Kitchen Creek was June 17. The leaf beetle was readily cultured in glass-topped sleeve cages as described by Gilstrap and Goeden (1974) on potted western ragweed, which itself is readily propagated vegetatively. Under insectary conditions, *O. notulata* completed a generation each month under continual culture for 27 generations. *Ophraella notulata* probably produces at least 3 generations annually at Kitchen Creek. The last generation, developing on mature plants in October and early November, was most numerous. Distribution of immatures and adults was patchy in 1981, but quite uniform in 1982, judging from sweep net samples along the margins of Kitchen Creek.

Mortality factors.—No parasites were reared from egg masses collected in the field. Egg predation by a large, red mite (Acarina: Anystidae) was observed. Partly and wholly collapsed eggs were commonly collected at Kitchen Creek. Larvae were fed upon by nymphs and adults of *Perillus splendidus* (Uhler) (Hemiptera: Heteroptera: Pentatomidae) in the field. *Chaetonodexodes vanderwulpi* (Townsend) (Diptera: Tachinidae) was reared as a solitary, endoparasite from prepupae collected in cocoons.

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